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DESCRIPTION

TORSIONAL DAMPER PULLEY

TECHNICAL FIELD

The present invention relates to a torsional damper pulley mounted on a revolving shaft of an internal combustion engine such as an engine of an automobile.

BACKGROUND ART

A pulley taking power for belt-driving of a radiator fan or the like from a crankshaft of an internal combustion engine is formed to be a torsional damper with an elastic solid being incorporated in it to absorb a torsional vibration of the crankshaft, and with an inertia mass in a pulley body.

As shown in FIG. 11, the torsional damper pulley is constructed of a hub 2 fixed to a crankshaft 1 of an internal combustion engine, an annular pulley body 3 coaxially placed outside the hub 2 in its diameter direction, and an elastic solid 4 interposed between an outer circumferential surface of an annular fixing portion 2a of the hub 2 and an inner circumferential surface of the pulley body 3. A pulley groove 3a in a suitable shape corresponding to a shape of a surface of a driving belt is provided at an outer circumferential portion of the pulley body 3 around which the driving belt is passed. The

pulley body 3 is produced to have the inertia mass corresponding to a difference in a vibration characteristic due to a difference in an internal combustion engine to which the damper pulley 3 is applied, such as a difference in a vehicle type on which the internal combustion engine is loaded, for example.

Conventionally, the pulley body 3 is produced mainly by the following two methods. One of them is a method of cutting an annular solid material to obtain an annular element of a desired size and form a pulley groove on its outer circumferential portion. The other one is a method of casting an annular element having a pulley groove on its outer circumferential portion, and finishing the annular element and the pulley groove by cutting.

The above-described cutting method requires enormous efforts and causes much waste of material with a large cutting amount. On the other hand, the casting method requires cutting to eliminate roughness on a cast surface and provide size precision, which makes the manufacturing process a little complicated, but since the rough body of the pulley body is obtained by casting, the method is rich in manufacturability and causes less waste of material with less cutting amount as compared with the cutting method. Accordingly, casting is more frequently used for manufacturing of pulley bodies in general.

However, the casting method lacks in general versatility, because if the internal combustion engines to which the damper pulleys are applied are changed, it becomes necessary to prepare a

special casting die corresponding to the vibration characteristic of the internal combustion engine. There also exits the problem of high cost of facilities since the cost of the facilities including the casting die are expensive.

For the above reason, the development of a torsional damper pulley is desired which is excellent in general versatility and is produced easily with reduced manufacturing cost.

Consequently, an object of the present invention is to provide a torsional damper pulley, which is improved in general versatility, easily produced, and makes it possible to reduce manufacturing cost.

DISCLOSURE OF INVENTION

In order to solve the above-described object, the present invention is a torsional damper pulley comprising a hub fixed at a revolving shaft of an internal combustion engine, an annular pulley body substantially rectangular in section, which is coaxially placed outside the hub in its diameter direction, has a pulley groove at an outer circumferential portion and has a predetermined inertia mass, and an elastic solid interposed between an outer circumferential surface of the hub and an inner circumferential surface of the pulley body, characterized in that the pulley body comprises an annular frame substantially U-shaped in section, which has a concave portion open in its axial direction and has a pulley groove at an outer circumferential

portion, and an annular inertia mass element fixed in the concave portion.

In the present invention, the pulley body is constructed by the frame having the pulley groove and an inertia mass element attached to the frame, and therefore manufacturing of the pulley body is facilitated. Even if the internal combustion engine is changed to an internal combustion engine with a different vibration characteristic, it can be handled by replacing the inertia mass element corresponding to the vibration characteristic of the internal combustion engine, and therefore general versatility of the damper pulley is enhanced. The frame can be formed by cold forging or pressing work of the plate material, and therefore the number of working process steps and working time can be reduced.

According to the present invention, it is preferred that the inertia mass element be formed by overlaying a plurality of annular plates on each other and bonding them. Thus, the mass of the inertia mass element can be easily adjusted by increasing and decreasing the number of annular plates to be laminated, increasing and decreasing the specific gravity of the annular plates, and the like. Accordingly, the adjustment of the mass of the inertia mass body corresponding to the vibration characteristic of the internal combustion engine to which the damper pulley is applied can be facilitated, and general versatility of the damper pulley can be further improved. Since

all the work for the pulley body and the hub including the inertia mass element can be made only by a press, it is possible to produce the damper pulleys through a production line, and thus the cost of the damper pulleys can be reduced.

An adhesive can be used for bonding the laminated annular plates, but in order to improve productivity, it is preferred to form the engaging pieces at the annular plates and mechanically bond them by a press. According to the present invention, cut-and-bent pieces are formed on a surface of the annular plate with spaces between them in a circumferential direction, and by overlaying a plurality of annular plates on each other so that the cut-and-bent pieces are overlaid on each other and pressing them, the plurality of annular plates can be bonded. Alternatively, dowels protruded from one surface of the annular plate to the other surface are formed on the annular plate with spaces between them in a circumferential direction, and by overlaying a plurality of annular plates on each other so that the dowels are displaced in the circumferential direction and pressing them, the plurality of annular plates can be bonded. In this case, it is preferred that a convex portion of the dowel is formed to be narrower than a concave portion. Thus, the bite of the convex portion into the surface of the annular plate becomes sharp and biting force increases, and bonding strength of the annular plates to each other is increased. In addition, the shape stability of the obtained inertia mass body is improved.

According to the present invention, it is preferred that the annular plate be formed by joining a plurality of arc-shaped ring pieces in an annular form. The annular plate may be punched out in its entirety by a press, but if a plurality of parts are assembled to form the annular plate, waste of the material can be eliminated. According to the present invention, a plurality of ring pieces are placed in an annular form, and by close-fitting a protruded piece formed at one end of one ring piece of the adjacent ring pieces into a hole formed at a corresponding one end of the other ring piece, a plurality of ring pieces are joined in the annular form. In this case, a concave portion can be formed at least at one side of a base portion of the protruded piece of the ring piece, and a protruded portion fitted in the concave portion is formed at a corresponding side of an open end of the hole. Thus, even if the hole is pressed to expand by the protruded piece on press-fitting of the protruded piece and the hole, deformation is pressed down and absorbed at the fitting portion of the convex portion of the base of the hole and the concave portion of the base of the protruded piece, and therefore the outer portion of the ring piece in the radius direction is securely prevented from opening outward.

An adhesive can be used to fix the inertia mass element in the concave portion, but the inertia mass element can be fixed by being press-fitted into the concave portion for simplicity. According to the present invention, the inertia mass element

comprises an annular plate having an inner diameter to be in pressure-contact with an inner surface of the inner circumferential wall for defining the concave portion of the pulley body, and the inertia mass element is fixed by being press-fitted into the concave portion. Alternatively, the inertia mass element comprises an annular plate having an outer diameter to be in pressure-contact with an inner surface of an outer circumferential wall for defining the concave portion of the pulley body, and the inertia mass element is fixed by being press-fitted into the concave portion. Alternatively, the inertia mass element comprises a first annular plate having an outer diameter to be in pressure-contact with an inner surface of an outer circumferential wall for defining the concave portion of the pulley body, and a second annular plate having an inner diameter to be in pressure-contact with an inner surface of an inner circumferential wall for defining the concave portion, and the inertia mass element is fixed by being press-fitted into the concave portion. Furthermore, the inertia mass element may be fixed to the concave portion of the pulley body with fastening means including a bolt.

According to the present invention, convex portions outward or inward in a diameter direction may be provided at the same positions in a width direction of the outer circumferential portion of the hub and an inner circumferential wall for defining

a concave portion of the pulley body. Thus, the elastic solid can be surely prevented from falling off.

According to the present invention, a wall portion for connecting an inner circumferential wall and an outer circumferential wall for defining the concave portion of the pulley body is omitted, whereby the concave portion is formed to be a through-hole open to both sides in an axial direction, the inertia mass element can be formed by overlaying a plurality of annular plates on each other and bonding them so that at least one annular plate having an inner diameter and outer diameter to be in pressure-contact with the inner circumferential wall and outer circumferential wall is placed, and the inertia mass element is pressure-fitted into the through-hole.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a sectional view (a) showing an essential part of one embodiment of a torsional damper pulley of the present invention, and an exploded view (b) showing press-fitting of an inertia mass element into a concave portion of a frame of the damper pulley;

FIG. 2 is a sectional view showing an essential part of another embodiment of the present invention;

FIG. 3 is a sectional view showing an essential part of still another embodiment of the present invention;

FIG. 4 is a sectional view showing an essential part of yet another embodiment of the present invention;

FIG. 5 is a sectional view showing an essential part of still another embodiment of the present invention;

FIG. 6 is a sectional view showing an essential part of yet another embodiment of the present invention;

FIG. 7 is a plan view showing a ring piece used for an annular plate of the inertia mass element of the damper pulley of the present invention;

FIG. 8 shows a plan view (a) for showing an improved joining portion by close-fitting for joining the ring pieces in FIG. 7 to each other and plan view (b) for showing a joining portion before improvement;

FIG. 9 is a sectional view (a) showing annular plates bonded with dowels and an enlarged sectional view (b) of the dowel;

FIG. 10 is a sectional view showing bonding of the annular plates to each other by a pin usable in the present invention; and

FIG. 11 is a sectional view showing a conventional torsional damper pulley.

BEST MODE FOR CARRYING OUT THE INVENTION

Embodiments of the present invention will be explained in detail below based on the drawings.

FIG. 1 is a sectional view showing an essential part of one embodiment of a torsional damper pulley of the present invention.

The torsional damper pulley is constructed of a hub 11 fixed with a bolt at a revolving shaft of an internal combustion engine, for example, a crank shaft (not shown) of an automobile engine via a mounting hole 11a, an annular pulley body 10 coaxially placed outside in a diameter direction of an annular fixing portion 11b on an outer circumference of the hub 11, and an elastic solid 13 interposed between an outer circumferential surface of the annular fixing portion 11b and an inner circumferential surface of the pulley body 10.

The pulley body 10 is constructed of an annular frame 12 substantially U-shaped in section, having a concave portion 15 open at one side in its axial direction, and an annular inertia mass element 14 axially inserted and fixed in the concave portion 15 of the frame 12. The frame 12 is formed of an inner circumferential wall 12a, an outer circumferential wall 12b and an orthogonal wall 12c for connecting them, which defines the above-described concave portion 15 inside to be a substantially U-shaped in section. On an outer surface of the outer circumferential wall 12b of the frame 12, provided is a pulley groove 16 in a suitable shape corresponding to the shape of the surface of a driving belt (not shown) to be passed around the outer surface of the outer circumferential wall 12b.

The inertia mass element 14 is a laminate made by overlaying annular plates 14a on each other and bonding them, and the inertia mass element 14 is fixed by being press-fitted into the concave

portion 15. In this embodiment, an inner diameter of the annular plate 14a is made slightly smaller than an outer diameter of the inner circumferential wall 12a of the frame 12, and an inner circumferential surface of the annular plate 14a is brought into pressure-contact with an inner surface of the inner circumferential wall 12a. It is preferred to form a taper 12d at an end edge of the opening of the inner circumferential wall 12a of the frame 12 and expand the diameter of the concave portion 15 outward at the end edge of the opening in order to guide the inner circumferential surface of the inertia mass element 14 and facilitate press-fitting of the inertia mass element 14 into the concave portion 15.

An adhesive may be used instead of press-fitting to fix the inertia mass element 14 in the concave portion 15. An adhesive may be also used in addition to press-fitting. The concave portion 15 may be filled with a resin after the inertia mass element 14 is inserted into the concave portion 15. If the concave portion 15 is filled with the resin, it becomes possible to obtain an anti-rusting effect, and in addition, it becomes possible to prevent the inertia mass element 14 from falling off or being detached from the concave portion 15 even when abnormal vibrations add to the damper pulley.

A frame 12 including the pulley groove 16 can be formed by cold forging of a plate material or by press working of a plate material. As the plate material, a cold-rolled steel plate

defined by Japanese Industrial Standard JIS G3141 or a steel strip SPCC (for general purpose), SPCD (for drawing), SPCE (for deep drawing) and the like can be used. If the frame 12 is formed of a thin plate or a flexible material so that the inner circumferential wall 12a can be bent by press-fitting of the inertia mass element 14 into the concave portion 15, a compression force can be applied to the elastic solid 13, and durability against repeated expansion and contraction of the elastic solid 13 is increased.

An adhesive can be used to bond the annular plates 14a to each other to form the inertia mass element 14, but as will be described later, a bonding piece is formed at the annular plate 14, and by pressing the laminate of the annular plates, the annular plates can be mechanically bonded to each other with the bonding piece. The annular plate 14a itself can be formed by pressing work of a plate material. As for pressing work of the annular plate 14a, the annular plate may be punched out in its entirety, or arc-shaped ring pieces, which are a plurality of divided parts of the annular plate in its circumferential direction, may be punched, while engaging pieces are formed at the ring pieces at the same time, and the ring pieces may be bonded by a press to form the annular plate. As the plate material, SPCC, SPCD, SPCE and the like can be used.

The elastic solid 13 consists of a ring of an elastic material, for example, a ring of rubber formed by vulcanizing, and

this is attached by being press-fitted between the annular fixing portion 11b of the hub 11 and an outer surface of the inner circumferential wall 12a of the frame 12. The hub 11 is made by press-forming the plate material so that the hub 11 has the annular fixing portion 11b at its outer circumference.

According to the torsional damper pulley of this embodiment, the pulley body 10 is constructed of two devided parts, i.e. the frame 12 having the pulley groove 16 and the inertia mass element 14 mounted in the concave portion 15 of the frame 12, and therefore production of the pulley body 10 is facilitated. Since the frame 12 can be formed by cold forging or pressing work of the plate material, the number of process steps and working hours can be reduced. Further, all the works for the pulley body including the inertia mass element and the hub can be performed only by a press, and therefore it is possible to produce damper pulleys through a production line, whereby cost of the damper pulleys can be reduced.

Since the inertia mass element 14 is formed by laminating a plurality of annular plates 14a, the mass of the inertia mass element can be adjusted by increasing and decreasing the number of annular plates 14a to be laminated and thickness of the annular plates. By applying pressure to the inertia mass element 14 in the thickness direction by a press, the inertia mass element 14 having high size precision can be obtained. Accordingly, the mass adjustment of the inertia mass element 14 corresponding to the

vibration characteristic of the internal combustion engine to which the damper pulley is applied can be facilitated, thus making the damper pulley high in general versatility. The mass adjustment of the inertia mass element 14 can be also realized easily by using the annular plates with different specific gravities.

Since the elastic solid 13 exhibits a damping property by converting energy of the torsional vibrations into heat, the life of the elastic solid 13 is sometimes reduced when excessive torsional vibration is continuously applied to the damper pulley. If the annular plates with different outer diameters are laminated and gaps are provided at the outer circumferential portions between the annular plates, while an air hole for introducing a flow of air caused by rotation of the damper pulley from one direction and an air hole for discharging from the other direction are provided at the frame 12, the heat of the elastic solid 13 can be released outside via the frame 12, thus making it possible to improve durability of the elastic solid 13.

In the above-described embodiment 1, the inner diameters of all the annular plates 14a constructing the inertia mass element 14 are made smaller than the outer diameter of the inner circumferential wall 12a of the frame 12, and all the annular plates 14a are pressed in contact with the inner surface of the inner circumferential wall 12a, but the inner diameters of some of the annular plates 14a may be made smaller than the outer diameter

of the inner circumferential wall 12a and may be pressed in contact therewith.

FIG. 2 shows another embodiment of the present invention. This embodiment differs in the point that the frame 12 of the pulley body 10 in the damper pulley in FIG. 1 is changed to a frame 12A with the increased outer diameter. For example, the internal combustion engines having the same vibration systems may sometimes require the diameter of the damper pulley to be changed, for example, require an increase in the diameter for the reason of the difference in the size of the engine rooms, auxiliary machines, and the like according to the vehicle bodies.

In the damper pulley of the present invention, the inertia mass element 14 mainly bears the inertia mass of the pulley body 10 by dividing the pulley body 10 into the frame 12 and the inertia mass element 14, and therefore it is possible to keep the inertia mass of the frame 12A within an allowable range even if the outer diameter is changed. It is preferred to produce the frame 12A by using a material as light as possible to reduce an increase in the mass by the amount of the increase in the outer diameter.

FIG. 3 shows still another embodiment of the present invention. In this embodiment, the annular plate 14a of the inertia mass element 14 has a slightly larger outer diameter than the inner diameter of the outer circumferential wall 12b of the frame 12, the inertia mass element 14, which is press-fitted into

the concave portion 15 of the frame 12, is in pressure-contact with the inner surface of the outer circumferential wall 12b on the outer surfaces of the annular plates 14a, and the inertia mass element 14 is fixed in the concave portion 15.

According to the above pulley body 10, the outer circumferential wall 12b of the frame 12 is supported from inside with the inertia mass element 14, and therefore the outer circumferential wall 12b can be reinforced. Accordingly, it becomes possible to use for the frame 12 a thin plate material which for itself has possibility of deformation of the outer circumferential wall 12b when an excessive tensile force is exerted thereon from the driving belt passed around the pulley body 10.

In the above embodiment 3, all the annular plates 14a constructing the inertia mass element 14 is in pressure-contact with the inner surface of the outer circumferential wall 12b of the frame 12, but the outer diameters of some of the annular plates 14a may be made larger and only these annular plates may be in pressure-contact with the inner surface of the outer circumferential wall 12b.

FIG. 4 shows yet another embodiment of the present invention. In this embodiment, the inertia mass element 14 is formed by alternately laminating first annular plates 14a1 having outer diameters to be in pressure-contact with the inner surface of the outer circumferential wall 12b of the frame 12, and second annular

plates 14a2 having such outer diameters and inner diameters to be in pressure-contact with the inner surface of the inner circumferential wall 12a and the inner surface of the outer circumferential wall 12b of the frame 12.

If such an inertia mass element 14 is press-fitted into the concave portion 15 of the frame 12, the inner circumferential wall 12a and the outer circumferential wall 12b of the frame 12 are supported from inside of the inertia mass element 14, and therefore the inner circumferential wall 12a and the outer circumferential wall 12b can be reinforced.

In the above embodiment 4, the outer diameters of some of the annular plates 14a1 may be made larger to be in pressure-contact only with the inner surface of the outer circumferential wall 12b of the frame 12. The inner diameters of some of the annular plates 14a2 may be made smaller to be in pressure-contact only with the inner surface of the inner circumferential wall 12a of the frame 12. The annular plates 14a2 do not necessarily have to be pressed in contact with the inner surface of the outer circumferential wall 12b of the frame 12.

FIG. 5 shows still another embodiment of the present invention. In this embodiment, convex portions 11b1 and 12a1 outward in their respective diameter directions are placed at the same positions in the width direction of the annular fixing portion 11b of the hub 11 and the inner circumferential wall 12a of the frame 12. The convex portions 11b1 and 12a1 may be placed

at a plurality of spots along the circumferential direction. The convex portions 11b1 and 12a1 may be placed to face inward in the diameter directions.

According to the above, the elastic solid 13 press-fitted into a space between the inner circumferential wall 12a of the frame 12 and the annular fixing portion 11b of the hub 11 can be surely prevented from falling off.

In this embodiment, the inertia mass element 14 inserted into the concave portion 15 of the frame 12 is fixed in the concave portion 15 by inserting a bolt 17 from an outer surface of the orthogonal wall 12c of the frame 12 into the inertia mass element 14. As in this embodiment, fixing of the inertia mass element 14 does not have to be performed by press-fitting. As fixing means, a pin and an adhesive are also possible other than a bolt.

FIG. 6 shows yet another embodiment of the present invention. In this embodiment, the orthogonal wall 12c for connecting the inner circumferential wall 12a and the outer circumferential wall 12b of the frame 12 of the embodiment 1 is omitted, whereby the concave portion 15 is formed to be a through-hole open to both sides in the axial direction. Namely, the frame 12 is constructed by inner and outer annular strips.

Annular plates 14a3 have the inner diameters and outer diameters to be in pressure-contact with the inner surfaces of the inner circumferential wall 12a and the outer circumferential wall 12b. A plurality of annular plates 14a4 and 14a3 are overlaid and

bonded so that the annular plates 14a3 are located at both ends, whereby the inertia mass element 14 is formed. The inertia mass element 14 is press-fitted into the concave portion 15 in the form of a through-hole, so that the outer circumferential wall 12b is supported from inside with the inertia mass element 14.

Convex portions 11b1 and 12a1 inward in the respective diameter directions are placed at the same positions in the width directions of the annular fixing portion 11b of the hub 11 and the inner circumferential wall 12a of the frame 12 to prevent the elastic solid 13 from falling off.

According to the embodiment 6, not only the mass of the inertia mass element 14 can be increased and decreased by increasing and decreasing the number of the annular plates 14a (14a3, 14a4), but also the diameters of the annular plates to be used can be easily changed by changing the outer diameter of the annular strips constructing the outer circumferential wall 12b, and consequently, general versatility in increasing and decreasing the mass of the inertia mass element 14 is higher.

In any of the above embodiments, the elastic solid 13 is formed in advance, and this is press-fitted into a space between the annular fixing portion 11b of the hub 11 and the inner circumferential wall 12a of the frame 12, but a rubber material may be filled in the space between the annular fixing portion 11b and the inner circumferential wall 12a, and the filled rubber material may be vulcanized to be formed into the elastic solid 13.

The annular plate 14a of the inertia mass element 14 may be punched in its entirety by a press, but it is suitable to divide the annular plate 14a into a plurality of pieces and assemble them to form the annular plate. As shown in FIG. 7, arc-shaped ring pieces 21, which are a plurality of divided parts of the annular plate in its circumferential direction (for example, four or five parts), are punched from the long plate material 20, and by this punching, protruded pieces 21b are formed on the ring pieces 21 at one end, and fitting holes 21a fitted to the protruded piece 21b are formed at the other end at the same time. A plurality of ring pieces 21 are arranged in the circumferential direction to be placed in an annular form, the protruded piece 21b of one of the adjacent ring piece 21 is placed at the hole 21a of the other ring piece 21, so that the end portion of the ring piece 21 and 21 butt against each other, and the butted end portion is pressed to close-fit the protruded piece 21b into the hole 21a, whereby a plurality of ring pieces 21 are connected and formed into the annular plate.

If the ring pieces 21 are thus punched out of the plate material 20, as many the ring pieces 21 as possible, each of which has a predetermined linear length L, are taken from the plate material 20 having the width of the same width L or more, whereby waste of the material can be substantially eliminated.

On close-fitting of the protruded piece 21b and the hole 21a, the hole 21a is forced to expand by the protruded piece 21b, and

therefore the part around the hole 21a of the ring piece 21 is deformed in the radius direction, and the outer part of the hole 21a in the radius direction especially tends to open outward as shown in FIG. 8(b). More preferably, rectangular concave portions 21b1 are provided at both sides of a base part of the protruded piece 21b of the ring piece 21 as shown in FIG. 8(a), and rectangular convex portions 21a1 fitted into the rectangular concave portions 21b1 are placed at both sides of an open end of the hole 21a of the ring piece 21. If the concave portions 21b1 at the both sides of the base part of the protruded piece 21b of the ring piece 21, and the convex portions 21a1 at the both sides of the open end of the hole 21a of the ring piece 21 are fitted to each other, deformation can be pressed down and absorbed at the spot of the fitting portion of the convex portions 21a1 and the concave portions 21b1, and therefore the outer part of the hole 21a in the radius direction can be surely prevented from opening outward.

The concave portions 21b1 at a base portion of the protruded piece 21b and the convex portion 21a1 at the open end of the hole 21a may be formed only at an outer portion which easily opens. It is preferable that the concave portions 21b1 and the convex portion 21a1 are rectangular, because the rectangular shape provides a strong engaging force, but they may be formed to be circular and the like other than rectangular.

There is the case in which the annular plate 14a is pressed in the thickness direction to secure the dimension of the annular plate 14, and in this case, an expanding force is applied to the ring piece 21, but if the fitting portions of the convex portions 21a1 and the concave portions 21b1 are provided, excellent shape retainability of the ring pieces 21 is provided.

An adhesive can be used to bond the laminated annular plates 14a, but in order to improve productivity, it is preferred to form engaging pieces at the annular plates 14a and bond them mechanically by a press. The engaging piece is shown in FIG. 7, and in this example, a half blanking work is performed for a center part of the arc of the ring piece 21, and two half-blanked pieces (cut-and-bent pieces) 21c are bent and raised from the surface of the ring piece 21 to protrude.

After the ring pieces 21 are joined and formed to be the annular plate 14, a plurality of annular plates 14a are overlaid on each other so that the cut-and-bent pieces 21c are overlaid on each other. The laminate of the annular plates are pressed, and the cut-and-bent piece 21c of one of the overlaid annular plates is fitted into the hole portion of the cut-and-bent portion 21c formed at the other annular plate, whereby the annular plates are bonded to each other. The annular plates are bonded to each other in the close-contact state with substantially no clearance between them by deformation by a press.

It goes without saying that an annular plate with no joint, which is punched out in its entirety, may be used for the annular plate with the cut-and-bent pieces being formed, instead of the annular plate made by joining the ring pieces. For the annular plate with no joint, the cut-and-bent pieces are formed with spaces provided in the circumferential direction, and the laminate of the annular plates is similarly bonded by pressing.

Bonding may be performed by forming a dowel as a bonding piece. As shown in FIG. 9, a dowel 22 protruded from one surface of the ring piece 21 to the other surface is formed by a half pierce work by a press, and after the ring pieces 21 are joined to be formed into the annular plate 14a, a plurality of annular plates 14a are overlaid on each other so that the dowels 22 are displaced in the circumferential direction. It is preferred that the dowels 22 of every other annular plate 14a be overlaid on each other. Then, the laminate of the annular plates 14a is pressed, convex portions 22a of the dowels 22 of one of the overlaid annular plates 14a are bit in the surface of the other annular plate 14a, whereby a plurality of annular plates 14a are bonded. The volume of the plate material of the opposed surface, which is squeezed out by the convex portion 22a of the dowel 22 biting in the opposed surface, moves to a concave portion 22b of the dowel 22 to fill the concave portion 22b, and does not move in the outer circumferential direction and the like, and therefore high precision of the outer diameter dimension is provided. This also

bonds the annular plates 14a to each other in the close-contact state with substantially no clearance.

In this case, it is preferred to form the convex portion 22a of the dowel 22 to be narrower than the concave portion 22b. If the convex portion 22a is made narrower than the concave portion 22b, the convex portion 22a can be formed to be high by ejection by half-piercing work which obtains the convex portion 22a and the concave portion 22b at the same time. Accordingly, bite of the convex portion 22a into the surface of the annular plate 14 is sharpened, which increases the biting force, and bonding strength of the annular plates to each other becomes high. The shape stability of the obtained inertia mass element 14 is improved.

It goes without saying that the annular plate with the dowels being formed may be an annular plate with no joint, which is punched out in its entirety, instead of the annular plate made by joining the ring pieces. For the annular plate with no joint, the dowels are formed with spaces provided in the circumferential direction, and the laminate of the annular plates is similarly bonded by pressing.

According to the present invention, joining by means of pins, screws and the like may be performed in addition to or instead of the joining by means of the dowels and the like of the annular plates 14a. A joining method by means of the pins is shown in FIG. 10. Pin holes 24 are formed at a plurality of spots in the circumferential direction of the annular plate 14a. The annular

plate 14a may be the one that is punched out in its entirety by a press as the conventional ones, or may be the one that is made by joining the arc-shaped ring pieces that are punched out, and on the punching, or after the punching, holes 24 are formed by pressing. A plurality of annular plates 14a are overlaid on each other so that the pin holes 24 are overlaid on each other, a pin 25 having conical concave portions 25a at its both ends is inserted into the pin hole 24 of the laminate of the annular plates 14a, choking jigs (not shown) of substantially the same shape are applied to the concave portion 25a at the both ends and pressed, and the pin 25 is choked by pressing the concave portions 25a to expand from the state shown by the chain double-dashed line to the state shown by the solid line, whereby the laminated annular plates 14a are bonded.

In this case, in order to prevent the end portions of the pin 25 from protruding outward from the laminate of the annular plates 14a, it is preferred to expand the diameter of the open ends 24a of the pin hole 24 of the annular plates 14a located at the outermost layer to an outside by chamfering or the like to make it possible to absorb deformation margin of the end portions of the pin 25. If the pin 25 is somewhat made shorter, the deformation margin is not always necessary.

As explained so far, according to the torsional damper pulley of the present invention, the annular pulley body substantially rectangular in section having a predetermined inertia mass is

constructed by an annular frame substantially U-shaped in section, having a concave portion open in its axial direction and having a pulley groove on its outer circumferential part, and an annular inertia mass element fixed in the concave portion, and therefore general versatility is improved, its production is facilitated, and reduction in the production cost becomes possible. Especially when the inertia mass element is constructed by overlaying a plurality of annular plates and bonding them, the mass of the inertia mass element can be easily adjusted by increasing, decreasing and the like of the number of laminated annular plates, and therefore general versatility of the damper pulley can be further improved.